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VI Congreso Internacional de Envolventes Arquitectónicas

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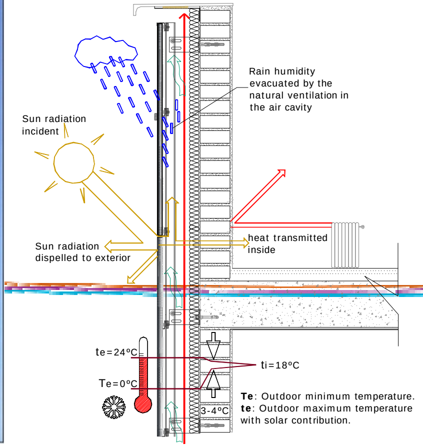
Acoustic Performance to Lightweight Ventilated Facade Prototypes Developed, Varying the External Cladding and the Opening to the Air Cavity

*A. Niampira Daza, **J.Ll. Zamora i Mestre***

2012 June 20th, 15:40 – 16.00 h



The lightweight facades with an external wall cladding that delimits an air chamber could be **more acoustic efficiently** than the traditional facades with a simple heavy wall; however **its capability has not been proven quite.**

This is because the opinion that the free air chamber ventilation seems **to limit the potential acoustic performance** of this ensemble.

This contribution is not contemplated clearly neither by the Spanish and European regulation for not being widely referenced.

The **question:** how much is the outside noise protection with the standard configuration on lightweight ventilated facade and how can improve:

- If **changes in the external cladding** standard configuration.
- If **variations in air chamber ventilation** from total open to zero.

This communication shows some **experimental results** obtained after evaluating **in situ** the acoustic performance of a heavy wall real façade before and after applying **three different prototypes** of wall cladding developed and installed for this purpose, and varying the air chamber ratio ventilation in the upper and lower perimeter.

This research is part of a **doctoral thesis**.

In Spain there are **no specific regulations** for lightweight ventilated facade systems. Consequently, the Codigo Técnico de la Edificación needs to be applied.

The lightweight ventilated facade system is only **partially defined** and neither limit values nor evaluation criteria are determined.

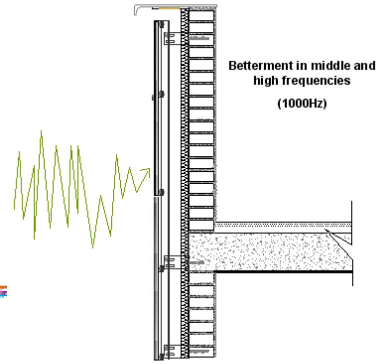
In the CTE DB-HR the values of requirements and verification are established for entire façade but the evaluation criteria only apply to the inner wall of the system which is the only element that requires compliance.

Neither the **air cavity** nor the **external cladding** is including as an element that improves the acoustic performance of the façade

In the European Union the European Technical Approvals Guidelines (ETAG) are taken as a **benchmark;** these documents contain the requirements for the use to the external claddings in lightweight facades.

The document DITE 034 - Kits for External Wall Claddings (DRAFT ETAGE Nº12) is used to approve lightweight systems. It defines the thickness of the ventilated air cavity and the minimum values of ventilation surfaces in the air cavity.

However this document **does not establish any criteria for assessing the contribution to acoustic protection**.



According to some authors when an external wall cladding with an intermediate ventilated air cavity is added to a conventional façade, the acoustic insulation of the resulting façade unit could increase almost to 7 dBA. *However the **real improvement** with this façade system probably fluctuates between 3 and 4 dBA in the middle-high frequency range (1000Hz).*

To further reduce low frequencies range (that are prevalent in external noise in cities) the **superficial mass of the cladding or the thickness of the air cavity can be increased**. This is not an easy option in lightweight commercial systems.

A non-ventilated air cavity in a double wall increases the acoustic insulation of the unit in the middle-high frequency range **if an acoustic absorbent material is placed inside the cavity**. There are no studies on the possibility of establishing a graded level of ventilation in the air cavity and its influence on noise protection.

SITUATION OF CURRENT REGULATIONS (3)

It was designed and built 3 models of lightweight ventilated façade using **different configurations of external wall claddings** and the same thickness in the air cavity in each case. It was established a **graded level of ventilation** in each model, by varying the opening of the ventilation surface of the air cavity (5 positions).

These 3 models were installed in a real façade on ETS Arquitectura del Vallès (UPC) on a section of wall with no openings in the posterior façade (north facing). The trial area was 9,60m wide x 6,00m high and corresponds to the first floor of the building; inside the space is a student rest room. The total surface in the room is 132,87 m2 and the volume is 660,8 m3.

The acoustic trials were performed according to the ISO regulations.

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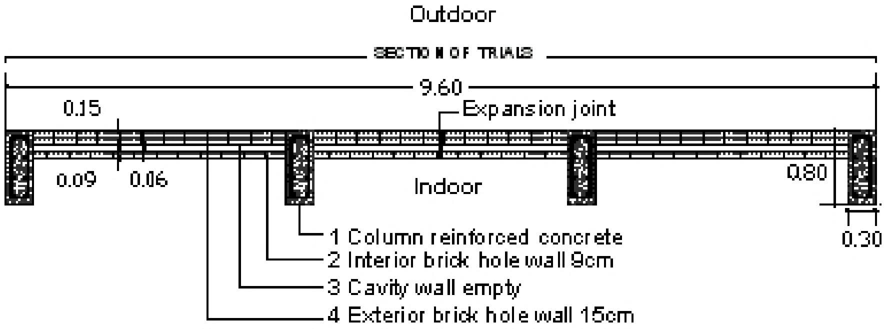
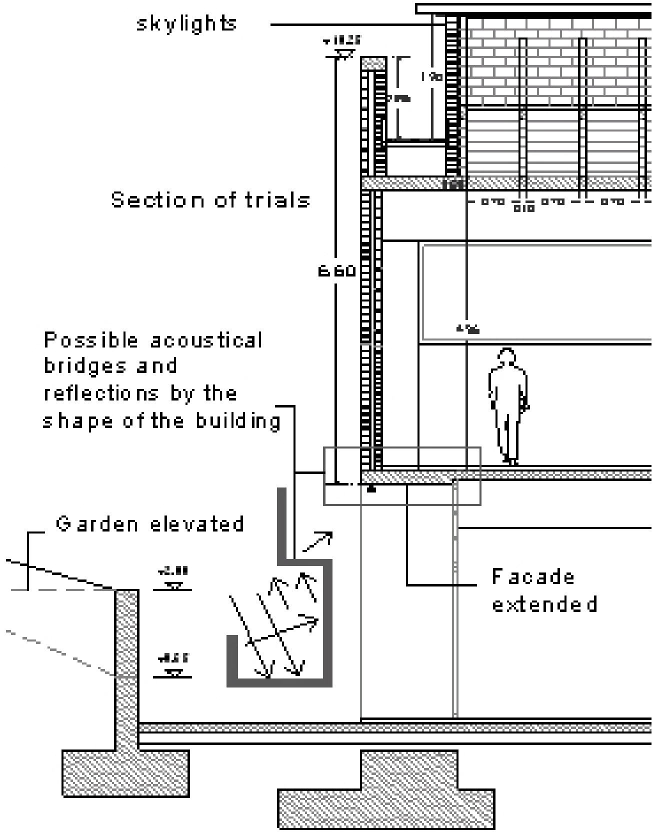


Bottom plan



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FIELD TRIALS (2)

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The façade is a **30 cm thick double brick**. The wall is formed of two layers made of different kinds of brick 9cm and 14cm separated by an empty air cavity 7cm approx.

As the trial area was a section of the façade of a real building it had **some irregularities to consider:**

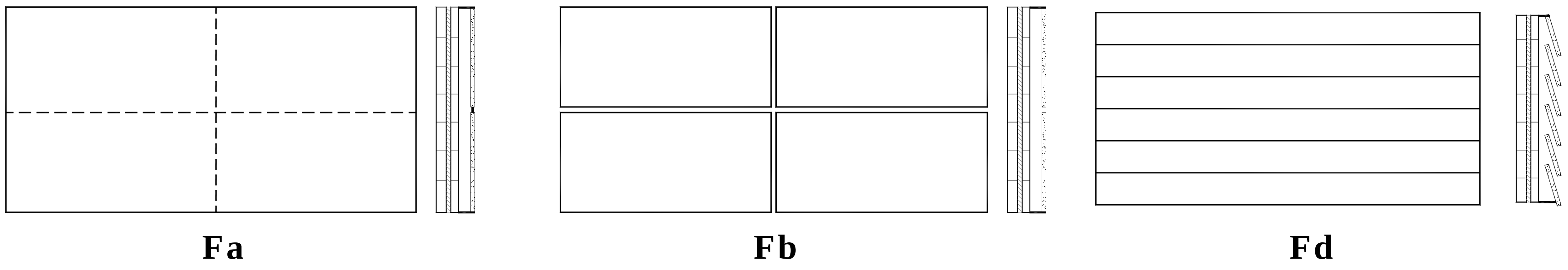
- In the middle of the study area of the façade there is an **expansion joint** between two stages in the construction of the building.
- The inner ceiling of the room contains **skylight**s made of extruded polycarbonate.
- The lateral enclosures of the room are partitions **made of aluminium frames and glass**.
- The floor is a **reinforced concrete base** of 20cm thickness with the overall rate of noise reduction R highest than the original façade wall base of trial.

Definition of the prototype models (1)

Fa, lightweight external cladding made of “Aquapanel Knauf” standard glass reinforced concrete (GRC) panels, with **sealed joints** between the panels.

Fb, lightweight external cladding made of “Aquapanel Knauf” standard glass reinforced concrete (GRC) panels, with **open joints** between the panels.

Fd, lightweight external cladding louvers made of “Aquapanel Knauf” standard glass reinforced concrete (RGC). The **louvers are overlap** with the same distance between each one.



Definition of the prototype models (1)

Fa, lightweight external cladding made of "Aquapanel Knauf" standard glass reinforced concrete (GRC) panels, with **sealed joints** between the panels.

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Fb, lightweight external cladding made of “Aquapanel Knauf” standard glass reinforced concrete (GRC) panels, with **open joints** between the panels.

Definition of the prototype models (1)

Fd, lightweight external cladding louvers made of "Aquapanel Knauf" standard glass reinforced concrete (RGC). **The louvers are overlap** with the same distance between each one.

Definition of the prototype models (2)

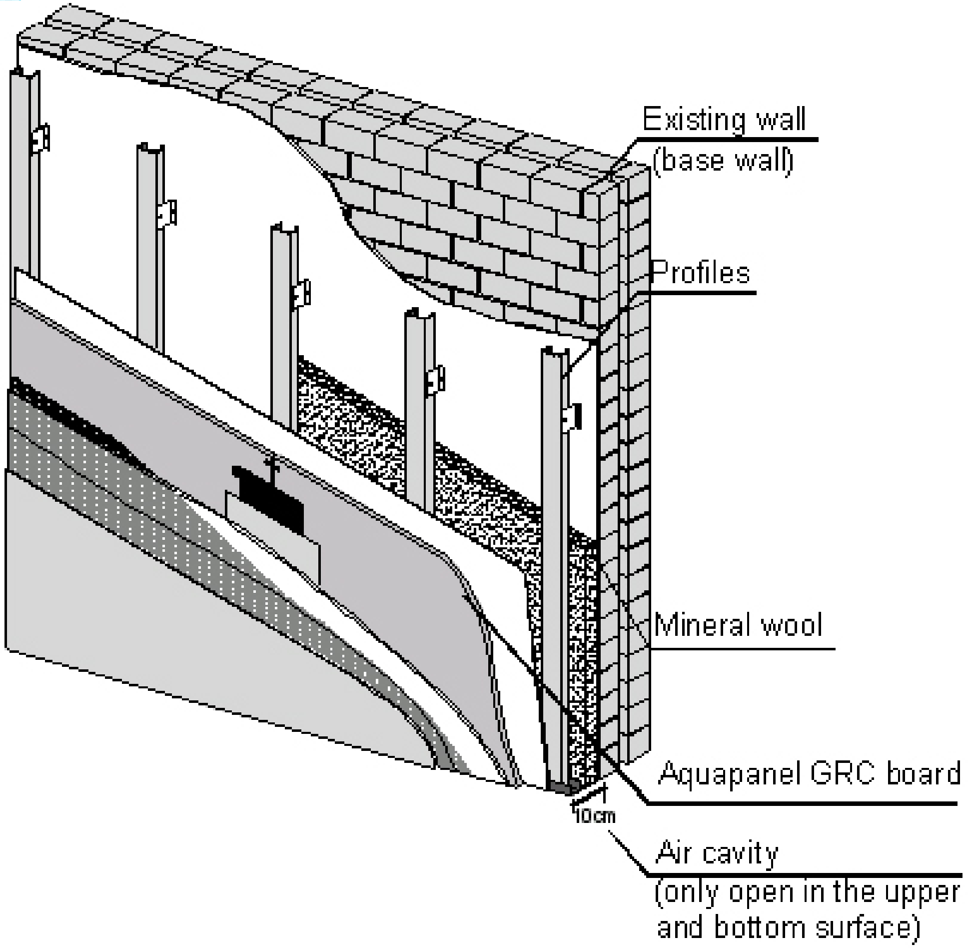
The “Aquapanel Knauf” RGC panels (2,40mx1,20mx12,5mm) were **screwed** onto a substructure of 50x50mm sections made of **galvanized steel** fixed at the base wall of the façade by 78mm brackets.
The model Fd model had a slightly different substructure to provide the slope needed for the 50mm overlap in the louvers with a 10mm distance between each one.

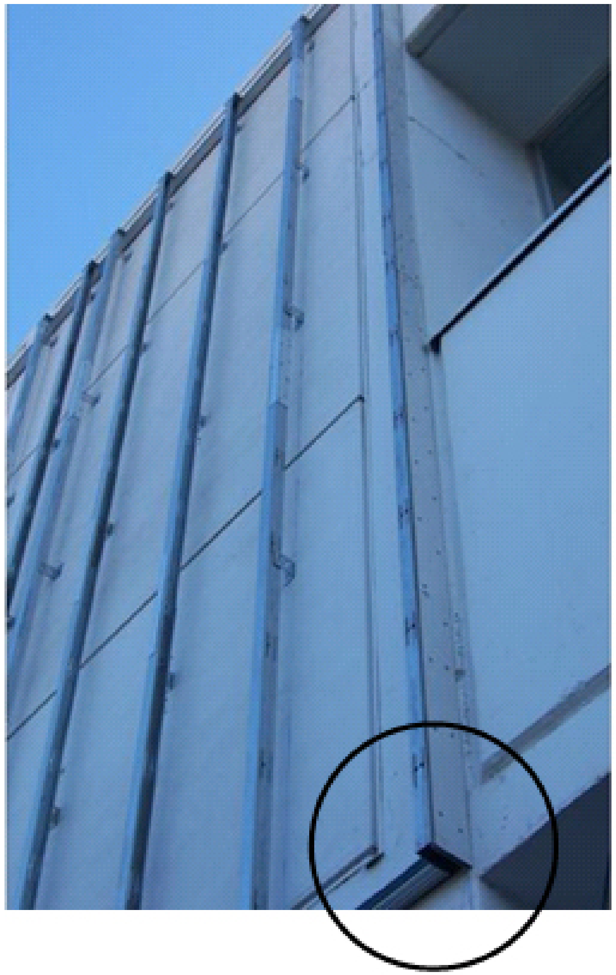
The **air cavity** in the models was **100mm wide** and obtained by joining two sections of 50x50mm galvanized steel.

Both **vertical perimeters** of the air cavity in the prototype models were **totally closed.**

A 40mm **mineral wool layer** was installed inside the air cavity and attached to the base wall.

Lightweight ventilated facade installation



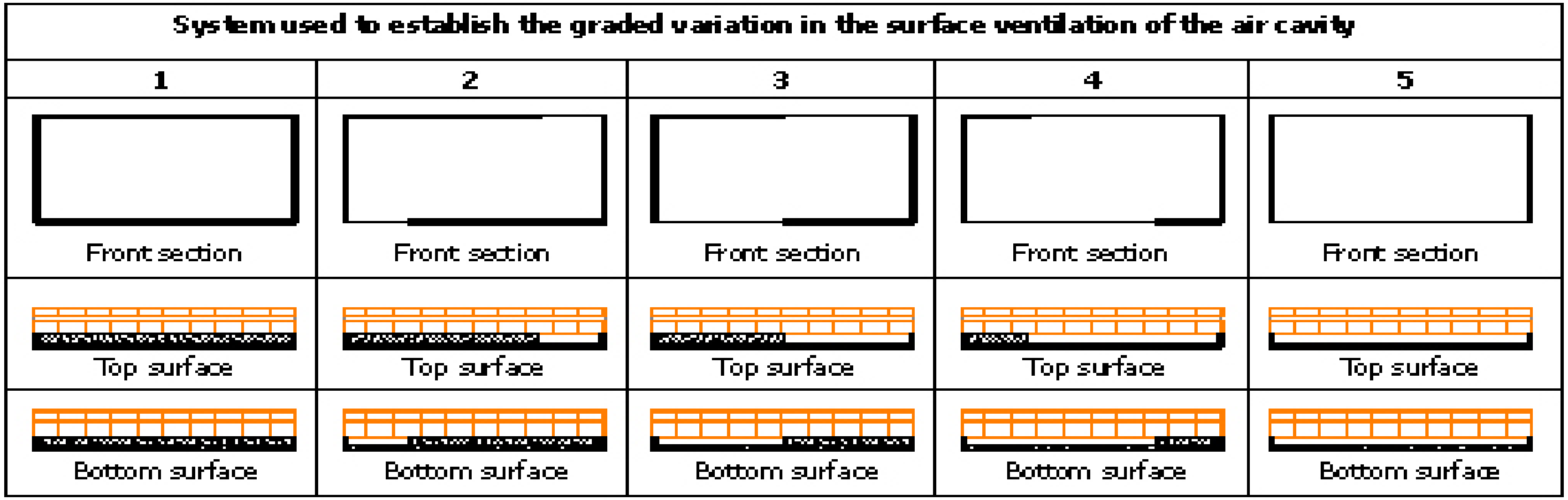


FIELD TRIALS (9)

2012_06_14

Definition of the prototype models (3)

The grades variation in the opening of the air cavity's ventilation surface was established by **segmenting the upper and lower horizontal perimeter** of the prototype model into **5 areas**. This was achieved using part of panels of Aquapanel GRC which were **successively removed** during the acoustic trials as shown in the diagram below.



1(0% ventilated-closed) 2(25% ventilated) 3(50% ventilated) 4(75% ventilated) 5(100% totally ventilated)

Definition of the prototype models (3)

Ventilation system during the acoustical trials

Trial procedure (3)

The acoustic trials were carried out in accordance with the current standards for acoustic measurements UNE EN ISO 140-5, UNE EN 1235-3, UNE EN ISO 717-1 and taking into account CTE-DB-HR

and the technical and human support to from the Laboratori d`Enginyeria Acústica i Mecànica de Terrassa, *Universitat Politècnica de Catalunya* (LEAM-UPC).

Measuring equipment

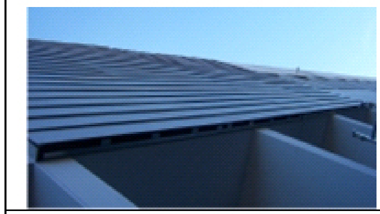
-Exterior sound source pink noise from a JBL model EON 15G2 loud speaker.

-The interior **LTS** was measured by an SLM SC310 CESVA type 1.0,1dB

-The exterior **LTS** was measured by a similar SLM using a mobile microphone.

The following table shows the overall results obtained with ***D2m,nTw***

$$D_{2\mathrm{m,nT}} = R' + \Delta L_{\mathrm{fs}} + 10\ \lg \frac{V}{6 T_0 S}\ \mathrm{dB}$$

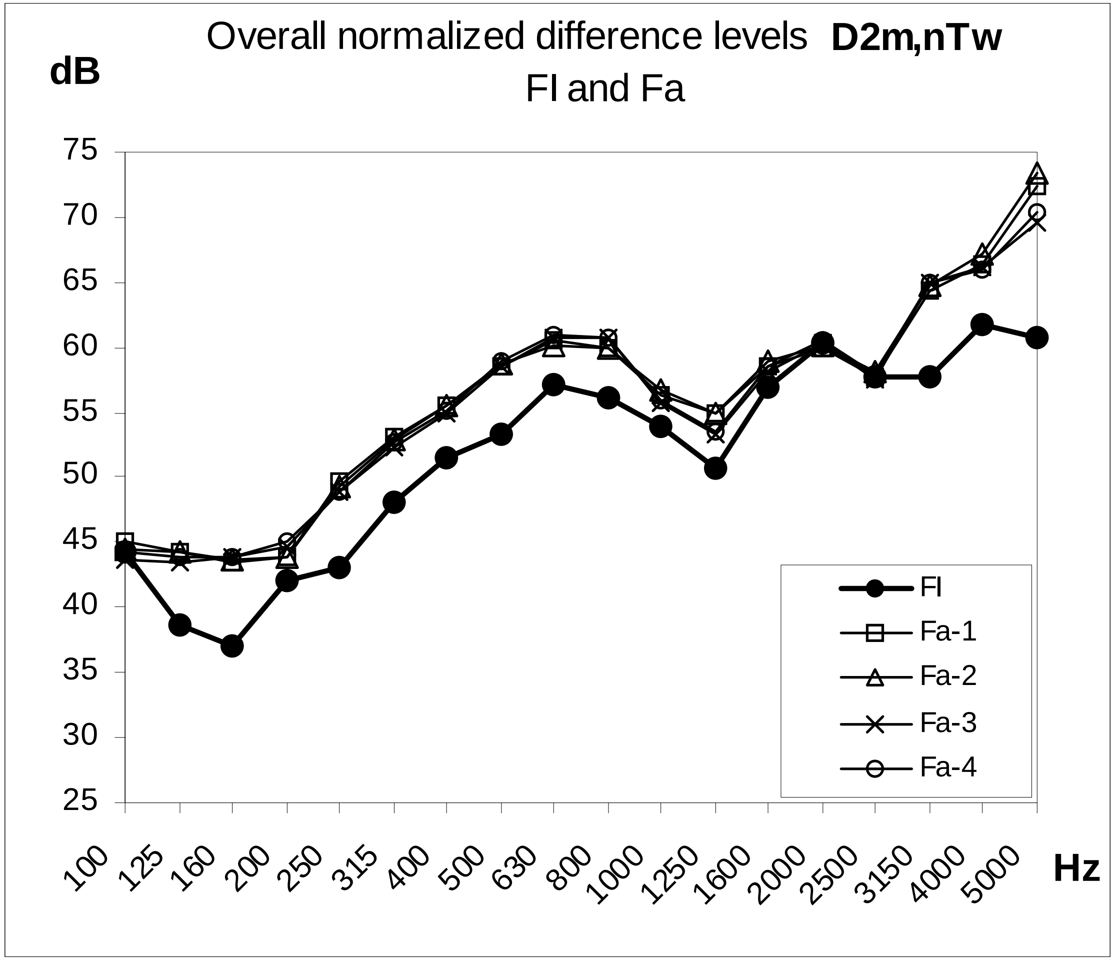
	**Fa prototype model (panels with sealed joints)**					**FI**
	Fa-1 0% ventilated	**Fa-2** 25% ventilated	**Fa-3** 50% ventilated	**Fa-4** 75% ventilated	**Fa-5** 100% ventilated	Original façade base wall
***D*2m,nTw**	58,5	58,7	58,5	59,0	36,0	53,3
	**Fb prototype model (panels with open joints)**					**FI**
	Fb-1 0% ventilated	**Fb-2** 25% ventilated	**Fb-3** 50% ventilated	**Fb-4** 75% ventilated	**Fb-5** 100% ventilated	Original façade base wall
***D*2m,nTw** (Extrapolated values)	55,0	56,1	55,4	54,3	57,4	53,3
	**Fd prototype model (louvers with and overlap between them)**					**FI**
	Fd-1 0% ventilated	**Fd-2** 25% ventilated	**Fd-3** 50% ventilated	**Fd-4** **75%** ventilated	**Fd-5** 100% ventilated	Original façade base wall
***D*2m,nTw**	39,0	55,0	55,4	56,2	56,8	53,3

SUMMARY OF RESULTS (1)

2012_06_18

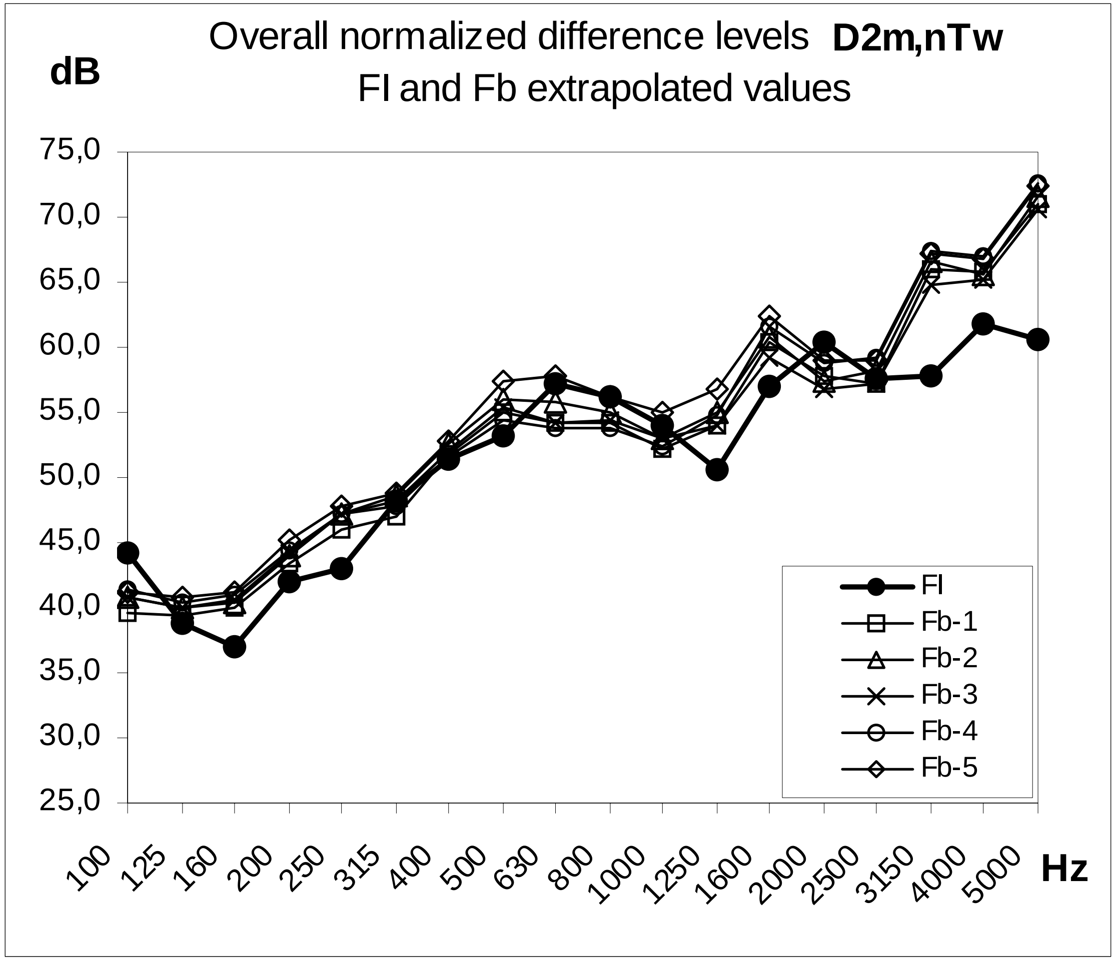
The following table shows the **Fa** results obtained with ***D*2m,nTw**

$$D_{2m,nT} = R' + \Delta L_{fs} + 10\lg\frac{V}{6T_0S}\ \mathrm{dB}$$



The following table shows the **Fb** results obtained with ***D2m,nTw***

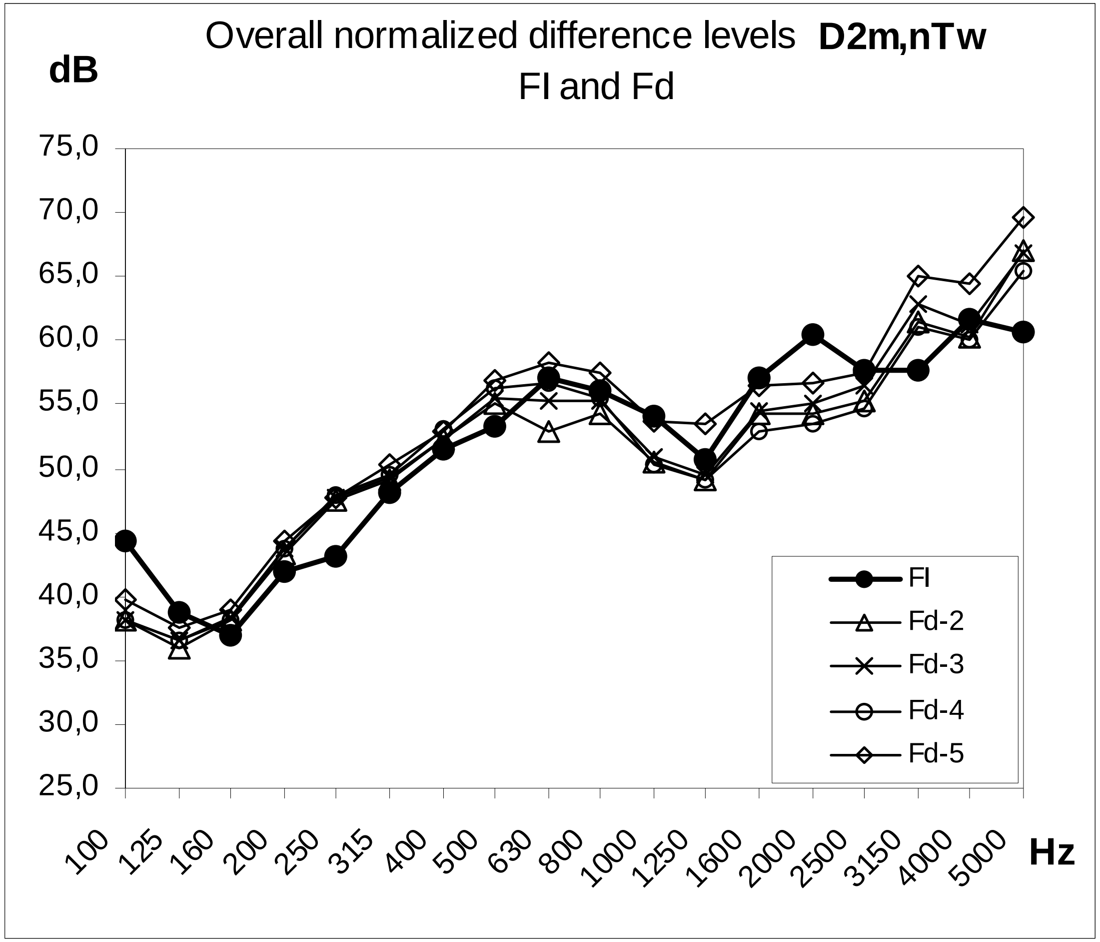
$$D_{2\mathrm{m,nT}} = R' + \Delta L_{\mathrm{fs}} + 10\ \lg \frac{V}{6T_0 S}\ \mathrm{dB}$$



SUMMARY OF RESULTS (3)

The following table shows the **Fd** results obtained with ***D*2m,nTw**

$$D_{2m,nT} = R' + \Delta L_{fs} + 10 \lg \frac{V}{6T_0 S} \text{ dB}$$



SUMMARY OF RESULTS (4)

1

The building and the room chosen for the trial give an idea of the singular features that could **complicated the evaluation** of sound insulation in the prototype models.

However the value obtained for the overall rate of noise reduction R’45º in the configuration FI 47,4dBA (original façade base wall with not prototypes) **is not far from the normal values tabulated** in the reference literature for a wall with similar characteristics (44dB RA).

2

There was a general improvement of around 5dB in the overall normalized difference in levels ***D*2m,nTw** when the Fa prototype model was used compared to the original façade FI. An improvement of around 3dB (extrapolated value) was found for the Fb prototype model and 2dB for the Fd prototype model with louvers when the air cavity was totally closed (without ventilation).

The five graded variations in the opening of the air cavity's ventilation surface in the different prototypes **did not seem to notably affect** the overall normalized difference in levels.

There are several possible reasons for this:

1) the effective **air layer was small**, due to the thickness of the air cavity (and was made even smaller by the mineral wool),

2) the influence of upper and lower ventilation surface in the prototypes as well as the system used to open the air cavity in comparison with the size of the entire façade and the volume of the room and

3) the perpendicular situation of the ventilation surface compared to the direction of the exterior sound waves.

4

In the frequency by frequency analysis of the results the trend of better noise reduction results was more pronounced **in the high frequency range**. Noise in this range can easily be reduced using existing solutions. In addition, there was an improvement in the **lowest frequency range**. This improvement was not as marked possibly due to the narrow thickness of the air cavity.

5

In general, the results **were positive and encouraging** given the real in situ circumstances in which this study was carried out. This study provides an approach to quantifying improvements in the acoustic performance of the lightweight ventilated façade systems with air cavities. It could form **the basis of future research in laboratory or with software simulations**. Future research in this area should focus on The thickness of the air cavity, to improve the results for the lowest frequency range in particular.

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Joan-Lluís Zamora i Mestre,
PhD Architecture

Programa de Doctorat “Ambits de Recerca en Energia i Medi Ambient a l’Arquitectura”

Universitat Politècnica de Catalunya (UPC)
BarcelonaTech
C/ Pere Serra,1-15
08173 St. Cugat del Vallès
joan.lluis.zamora@upc.edu
arquiniampira@yahoo.com

http://www.upc.edu/aie/

Thanks

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